# Space Weather Technical Forecast

Issued on Sunday, 28 November 2021 at 00:33 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

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**Space Weather Forecast Headline: Chance of G1/Minor Magnetic storms on Day 1 (28 Nov) due to CME arrival.**

**Analysis of Space Weather Activity over past 24 hours**
**Solar Activity:** Solar activity has been Very Low over the past 24 hours, with no significant X-ray flares. There are currently three active sunspot regions on the visible disc. AR2898 is classified Cai/Beta near southern centre disc, AR2990 is classified Dai/Beta in the southwest quadrant. A new spot has rotated over the northeast limb, currently classified Axx/Alpha although this may change as it becomes more fully visible. No Earth-directed CMEs have been observed in the last 24 hours. There are a number of filaments, however, most notably across the Sun's southwestern quadrant, and these will be monitored for any potential liftoff.

**Solar Wind / Geomagnetic Activity:** The solar wind, as measured by DSCOVR at L1, was at background levels for much of the period, before a CME arrival occurred at 27/2150 UTC. Wind speeds varied between 300-360km/s, before jumping from 300 up to 380 km/s when the CME arrived. The density has been at mostly average levels, then jumped to around 25 ppcc. The IMF, Bt, was weak at 6 nT or below, before reaching up to 15 nT with the CME arrival. The Bz was varying between +/-4 nT, but started to vary between +/- 6 nT after the CME. The phi angle was variable with some rotations, but tended towards more positive (away from the Sun) than negative values. Geomagnetic Activity was Quiet (Kp 0-1).

**Energetic Particles / Solar Radiation:** The high energy proton flux (greater than 10 MeV) remained at Background levels. The high energy electron flux (greater than 2 MeV) as observed by GOES-16 was at mostly Moderate levels, with a diurnal peak of 793 pfu at 27/1235 UTC. The associated 24-hour integrated fluence remained below the Active threshold (1e8 integrated pfu), with a falling trend from 27/1200 UTC, reaching 3.07e7 integrated pfu at 28/0000 UTC.

**Four-Day Space Weather Forecast Summary**
**Solar Activity:** Solar activity is expected to be Low or Very Low, with the possibility of C-class flares from either of the two more complex active regions currently on the disc. There is also an above background risk (5%) of isolated M-flares (R1 Blackouts).

**Solar Wind / Geomagnetic Activity:** The recent CME arrival has given some disturbed solar wind conditions, despite wind speeds remaining at ambient levels. A further CME from a filament eruption early on the 26 Nov has now been reassessed as likely missing, but with low confidence, giving a small chance of some impact at Earth late Day 2 or Day 3 (29 or 30 Nov). There may also be weak additional enhancements from coronal holes 22 or 24 on Day 1. Disturbed conditions from the CME are expected to settle over the next 24 hours or so. Geomagnetic activity is likely to be Unsettled to Active at first, with a chance of G1/Minor Storms on Day 1 (28 Nov). Conditions easing back to mostly Quiet to Unsettled thereafter, but with a chance of Active intervals if we do see a glancing blow from the second CME later in the period.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels. The high energy electron flux (greater than 2 MeV) is

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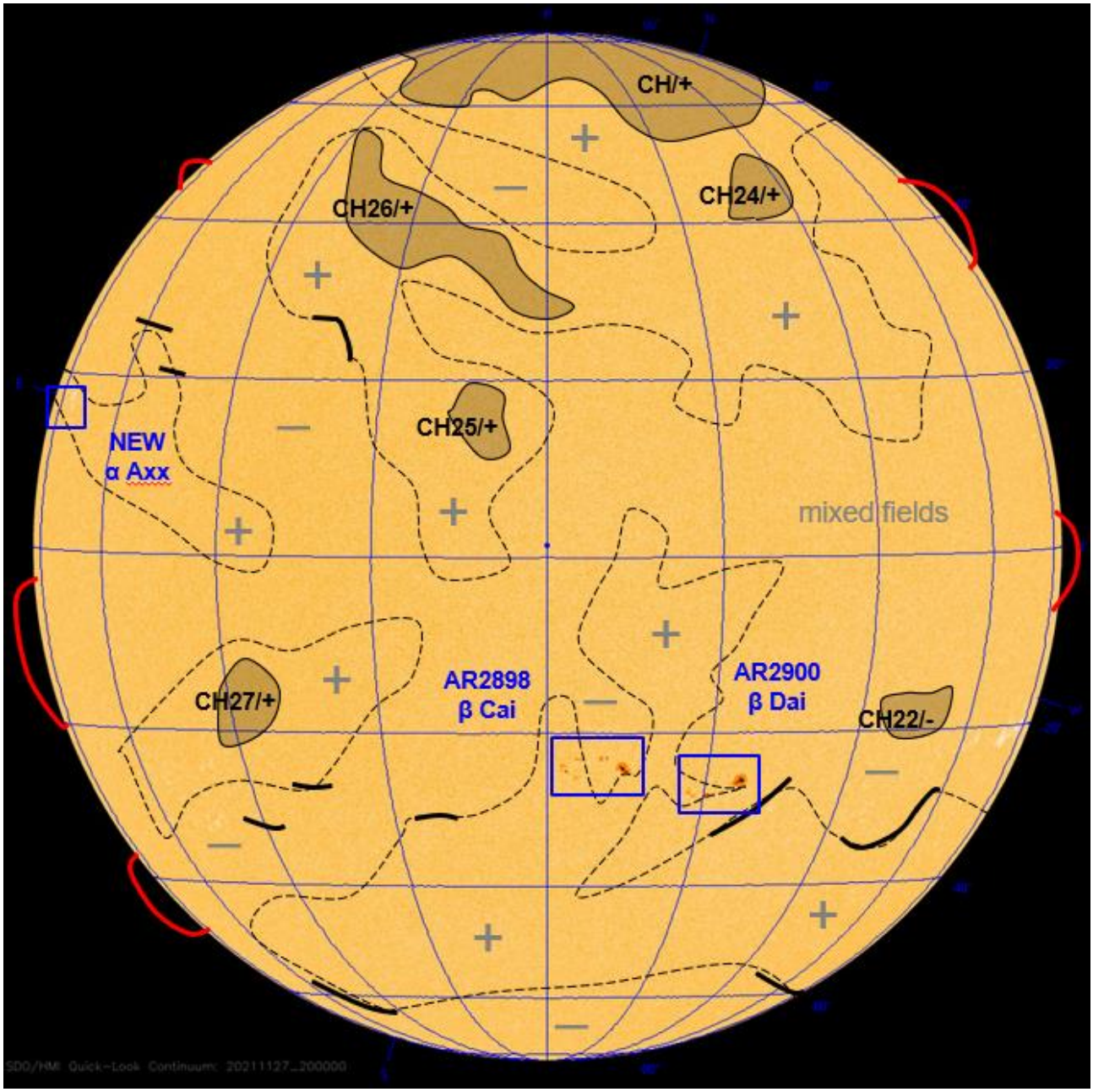
likely to be at Background to Moderate levels, with a low confidence possible increase due to the CME from Day 2 (29 Nov) onward. If this occurs, the fluence may rise as a result, but is currently expected to remain below the Active (1e8 integrated pfu) threshold.

**Figure 1. Solar Analysis Valid 27/2000 UTC.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

A CME arrived at L1 at 27/2150 UTC. This was due to a filament eruption which left the Sun at 24/1400 UTC. Whilst the bulk of material appears to be passing beneath the Earth, there is a component which has reached us. A further filament eruption was observed from the northeast disc around 26/0010 UTC, however analysis of any subsequent CME has been difficult due to limited good imagery. Whilst currently not expected, a glancing impact is possible late Day 2 (29 Nov) or on Day 3 (30 Nov).

Despite the CME arrival, solar wind speeds remain at ambient levels, although further weak enhancements are possible from the fast winds of either coronal hole 22 or 24 on early Day 1 (28 Nov). Any effects from this are likely to combine with the CME effects. Otherwise, any solar wind enhancements from the CME are expected to decline over the next 24 hours or so. Geomagnetic activity is likely to be Unsettled to Active at first, with a chance of G1/Minor Storms on Day 1 (28 Nov). Conditions easing back to mostly Quiet to Unsettled thereafter, but with a chance of Active intervals if we do see a glancing blow from the second CME later in the period.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 40 | 5 | 10 | 1 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

| Date/time 21.5R (UTC) | Halo: Full or Partial | Source | Source Location | Estimated Speed | Estimated Arrival Time | Comments |
|---|---|---|---|---|---|---|
| * | * | * | * | * | * | * |

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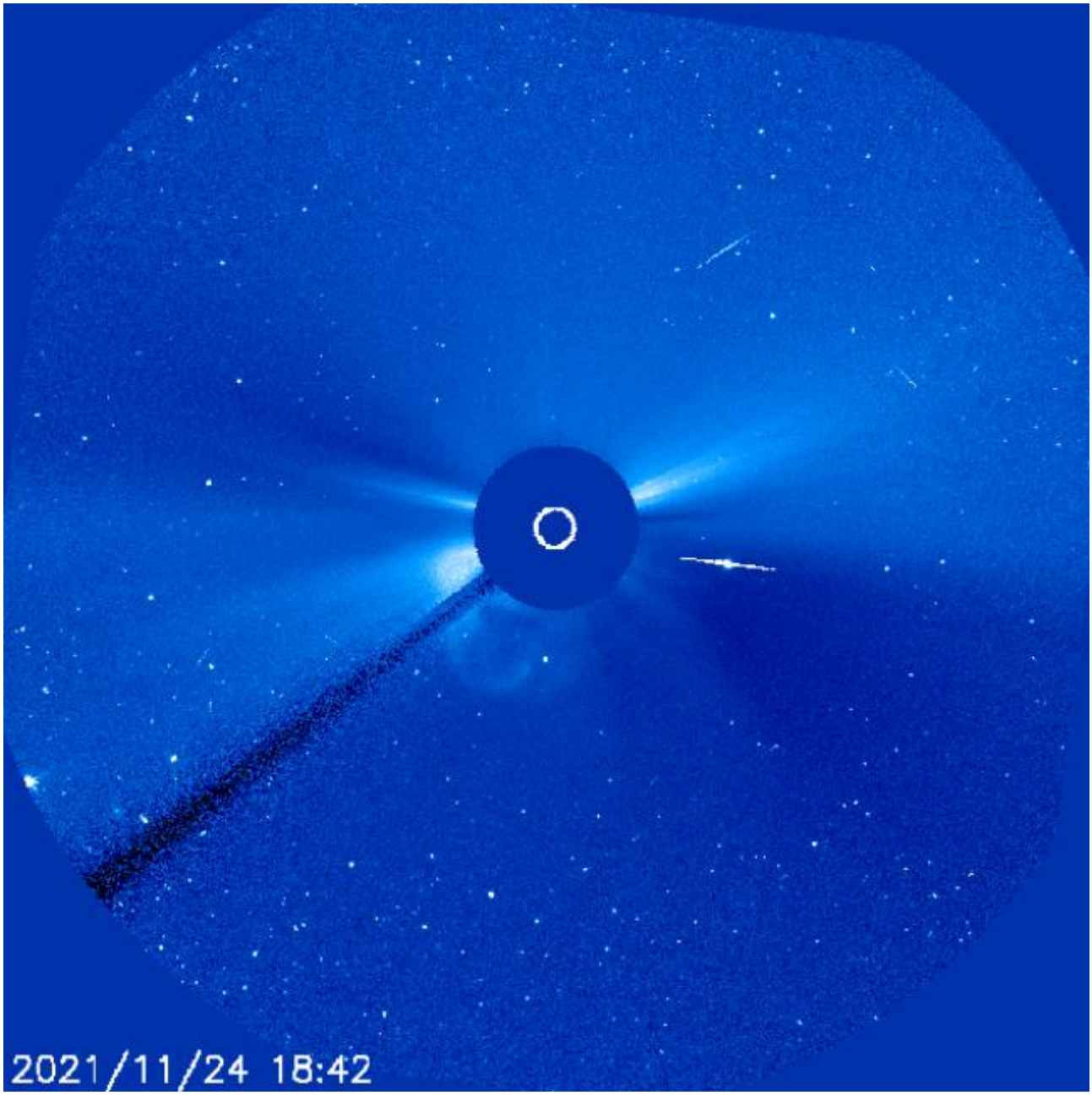
**Figure 2: The CME which recently arrived at Earth, as seen in SOHO coronagraph imagery.**

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## Radio Blackouts - X-Ray Flares:

There are now three active sunspot regions on the Earth-facing disc. AR2898 (Cai/Beta) is near the southern centre disc. AR2900 (Dai/Beta) is in the southwest quadrant. These are both relatively simple regions, with just some slight complexity, but little history so far of any flaring. A new region has rotated onto the northeast limb and currently appears to be a simple Alpha spot. However, we need it to become more fully visible before making a complete assessment. There is also a plage region in the southwest disc, approaching the limb, that contains the remnants of Ex-AR2899, and occasionally shows signs of slight pore development.
Solar Activity has been Very Low with only B-class X-ray flares observed by GOES-16/17. This has a may rise to Low, with the two more complex regions on the disc both having sufficient magnetic flux for C-class flares. There is also an above background risk (5%) of this increasing to moderate from M-flares (R1-Blackouts).

| X Ray Flares / Probability | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Active | R1-R2 M Class | No | 5 | 5 | 5 | 5 |
| Very Active | R3 to R5 X Class | No | 1 | 1 | 1 | 1 |

## Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (greater than 10 MeV) as observed by GOES-16 is forecast to remain at background levels, with no solar radiation storms anticipated.

| Radiation Storms / Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Active | ≥ S1 | No | 1 | 1 | 1 | 1 |
| Very Active | ≥ S3 * | No | 1 | 1 | 1 | 1 |

* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)

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**High Energy Electrons Event (≥ 2MeV):**
The high energy electron flux as observed by GOES-16 reached Moderate levels at the diurnal peak on 27 Nov, which was down from the previous day. Electron levels are expected to decline further with the recent CME arrival likely causing a temporary suppression in the flux. Once any initial geomagnetic disturbance has receded, there is the potential for Moderate to High electron flux levels to return from Day 2 (29 Nov) onward. However, current indications suggest the wind speeds are not that high associated with the CME, so may be insufficient to drive any significant flux increase.

The associated electron fluence is expected to remain below the Active threshold through the period. It is likely there will be a small period of decline, before fluence levels may possibly rise in response to the CME arrival, however this is low confidence.

| GEO Electron Environment | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability (Exceedance) | | | (%) | (%) | (%) | (%) |
| Active | ≥ 2 MeV ≥ $1x10^8$ | No | 1 | 5 | 10 | 10 |
| Very Active | ≥ 2 MeV ≥ $1x10^9$ | No | 1 | 1 | 1 | 1 |

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